

# User's Guide to the Wavetek / Krohn-Hite Drive Electronics

© Copyright 2002 MicroFab Technologies, Inc., Plano, TX, USA.  
All rights reserved.

The Wavetek/Krohn-Hite drive electronics consists of a Wavetek 395 waveform generator and a Krohn-Hite 7602M amplifier to provide pulses for operating piezo-driven fluid dispensers. It covers the ranges of operating parameters required by the MicroJet™ fluid dispensers of MicroFab Technologies, Inc. at all operating temperatures.

## **Safety Notice:**

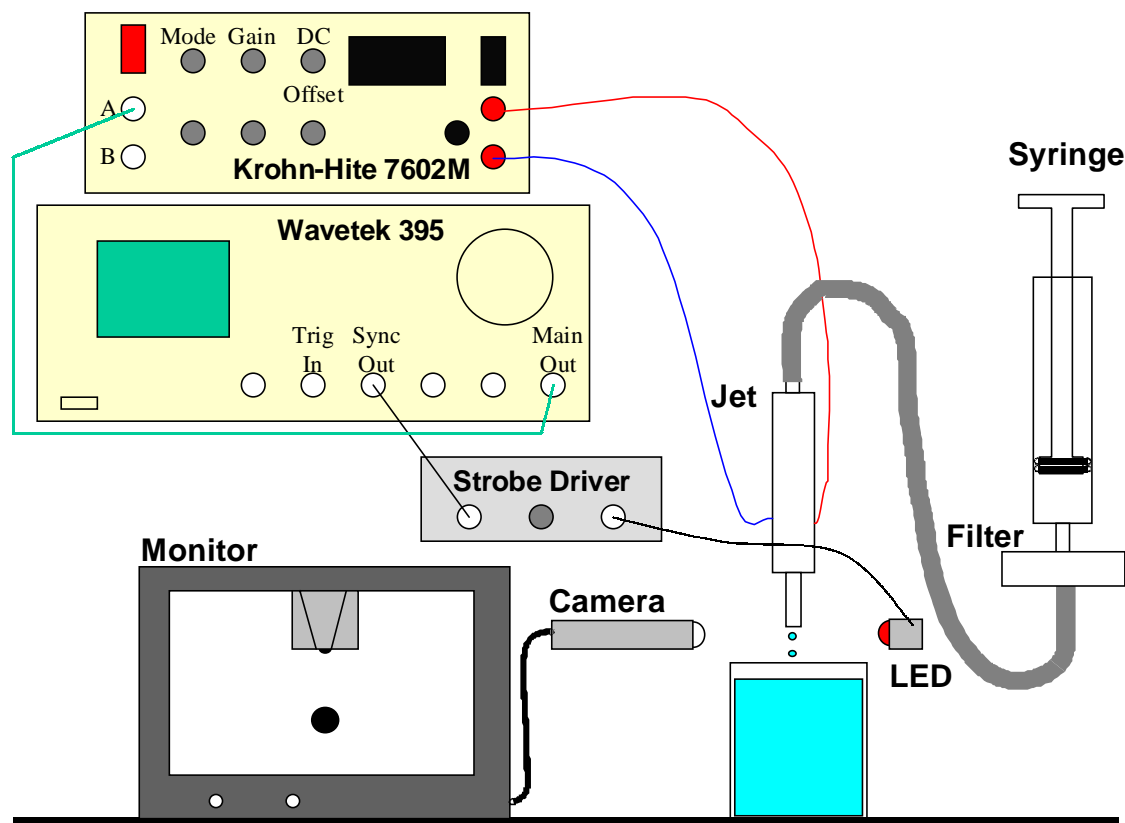
***The Krohn-Hite model 7602M is a powerful amplifier, capable of delivering peak voltages of +/-280 V with significant currents. Safety instructions provided in the manuals of the Wavetek 395 and Krohn-Hite 7602M have to be observed. In operation for maximum output range, both wires of the pulse cable will be fed with high voltage. It is therefore recommended safe practice to have the drive electronics system turned on only when it is to be used. The cable conducting the high-voltage output pulse must be protected against accidental contact by any person, and contact with any other electrically conducting materials. Before any work on the dispensing device, including connecting/disconnecting and mounting/dismounting, the drive electronics has to be turned off.***

## **Setup**

A simple test setup is shown in the figure below. The drive electronics is operated from a computer through a regular serial connection which plugs into the back of the Wavetek 395 (DTE to DCE; 9600 baud, 8 bits, no parity, 1 stop bit). A test program (MFWAVE32.EXE for Windows 95, 98, ME, NT 4 and 2000) for stand-alone operation is included with the drive electronics.

The voltage pulse is issued on the upper red binding post of the Krohn-Hite 7602M, including a possible DC offset, and the black binding post is kept at 0 V. For higher range, an inverted duplicate of the pulse is available on the lower red binding post. Using both red posts will therefore double the available range as the device is sensitive only to the difference between the two wires, and care must be exercised as now there is no defined ground nearby. The external trigger input (fed to the TRIG IN connector on the

Wavetek 395, if desired) and the strobe signal output (SYNC output of the Wavetek 395) operate with TTL type signals (5 V positive, BNC connectors).



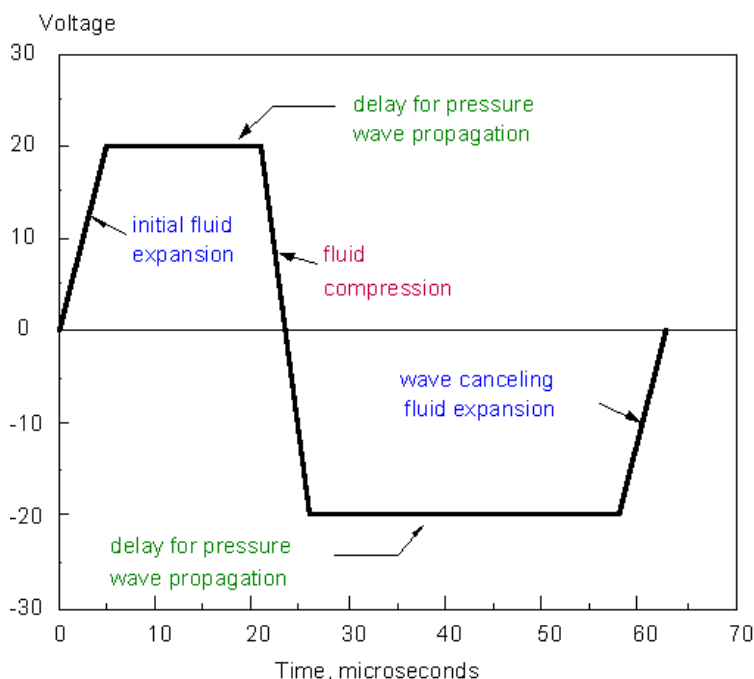
For observing droplets in flight, a strobed LED (order of 10  $\mu\text{s}$  long pulses), a black-and-white CCD camera and a monitor are the basic recommended equipment. The strobe output (SYNC OUT on the Wavetek 395) of the drive electronics is strictly meant to provide a timing/trigger signal and will have to be fed into a driving circuit for the strobe light. For this, a unit is available from MicroFab Technologies that also provides a delay to allow observation of various stages of the drop formation.

The following settings need to be used on the Krohn-Hite amplifier:

- Input onto connector A.
- Mode: Upper knob set to "A", lower knob set to "DC".
- Gain: Upper knob set to **highest** range (marked 28dB or 42 dB), lower knob turned to about 90% of maximum. Using the black and upper red output posts, the resulting gain should be found to be 112.5, using both red outputs, the gain should be found to be 225.
- DC Offset: Upper knob set to OFF. DC offsets can be programmed through the Wavetek 395 generator; the Krohn-Hite amplifier is DC stable.

## Principles of Operation

The MicroJet™ dispensers operate with piecewise linear unipolar or bipolar pulses as sketched in the following figure. The Wavetek/Krohn-Hite drive electronics allows to use



pulses, including possibly a DC offset, within the voltage range from  $-280\text{ V}$  to  $280\text{ V}$ . Most applications at room temperature will actually require the pulse amplitudes at less than  $40\text{ V}$ , in some cases even as low as  $10\text{ V}$ . The PC-based control program allows all three voltage levels (DC, positive pulse part, negative pulse part) to be adjusted in steps of  $1\text{ V}$ , and all rise, dwell, and fall times in steps of  $0.1\text{ }\mu\text{s}$ . At room temperature, the time values are usually set to whole microseconds. The rise and fall times in most cases are around  $3\text{-}5\text{ }\mu\text{s}$ , and the dwell times (durations of the positive and negative voltage pulse plateaus) are normally in the range  $15\text{-}50\text{ }\mu\text{s}$ . The PC program supports time values up to  $819\text{ }\mu\text{s}$  (for purely historical reasons; the Wavetek can support longer times). The falling edge of the positive pulse excursion effectively determines the release time of the drop from the MicroJet™ dispenser. Additional drops (“satellites”) or, more commonly, prevention of the same, can be controlled by varying the pulse shape parameters, foremost the pulse amplitude and to some extent the dwell times. Unipolar pulses are sufficient in many cases and can be accomplished by setting the voltage level of the negative excursion equal to the DC offset of the whole pulse shape.

Two operating modes are distinguished: “Single” mode, where a trigger generates a finite number of droplets ( $1\text{-}32767$  in the PC control program; again, the Wavetek can support a larger range), and “Continuous” where droplets are produced continuously until an explicit stop command is given. Triggers can come from one of two sources: internally generated following a corresponding command received from the host

computer, and externally through a TTL signal through the corresponding connector on the front panel. The leading edge of the TTL signal then defines the timing of the trigger.

## Using the Control Program MFWAVE32.EXE

MFWAVE32.EXE is a MS Windows console program to operate fluid dispensers through the Wavetek/Krohn-Hite drive electronics. It requires an Intel x86 architecture based PC, and can be run from the command line as well as in a console window of Microsoft® Windows™ versions 95, 98, ME, NT4 and 2000. To install, simply copy it to the desired location; no further setup is needed. Add "COM2" as an argument on the command line if the drive electronics is used on the COM2 port rather than COM1. To practice without hardware, use NOCOM as a command line argument. The program produces a log file MFWAVE.LOG recording all commands sent and their responses. This may be helpful in determining problems, reproducing sequences of commands, and as a reference for creating customized control programs.

The screenshot shows a Windows console window titled "MFWAVE32". The window contains the following text:

```

MicroFab Drive Program for Wavetek 395 Pulser vs. 03.00

      Pulse shape
      Time      Voltage
Idle           0.1 µs    0 U
Rise           0.1 µs
Dwell         120.0 µs    50 U
Fall           0.1 µs
Echo          180.0 µs   -50 U
Final rise     0.1 µs
Gain           225

      Trigger settings
Source         PC Trig.
Mode           Single
Drops/Trigger  1
Frequency      200 Hz
Strobe Divider 1
Strobe Enable  On

Press highlighted-letter keys to execute command.

Pulse   Trigger   Mode   Start   Reset   Exit
  
```

When starting the program, first a few messages appear at the bottom of the screen, then the full display as shown above follows. The highlighted letters in the row of commands near the bottom of the screen indicate the keys to press in order to execute the corresponding command. The input is *not* case-sensitive. The commands are used as follows:

<b>Command</b>	<b>Effect</b>
Pulse	Enter the "Pulse Shape" section on the screen to allow adjustment of the pulse shape parameters. Editing of parameters occurs by overtyping, and

	movement from one parameter to the next by use of the "Tab" key. Only forward tabbing is supported. The "Delete" and "Backspace" keys are not available, so typos have to be corrected by tabbing through all entries and overtyping the whole entry again. At every entry, a hint on what can be entered, and possibly an error message if warranted, is displayed.
Trigger	Enter the "Trigger Settings" section on the screen to allow adjustment of triggering parameters. Editing follows the same pattern as described for the "Pulse" command; the non-numeric entries are toggled by pressing the space bar.
Mode	Toggle the trigger mode in the trigger settings between "Single" and "Continuous". This is a short-cut to avoid having to use the "Trigger" command, tab to the mode entry and toggle the mode then.
Start	Generate a trigger for pulse output. If the trigger mode is "Continuous", the command displayed changes to "Stop" which then is available to stop dispensing in continuous mode.
Reset	Reset the drive electronics settings to start-up values.
Exit	Terminate the program.

If the drive electronics is turned off (intentionally or through a power outage), the control program (MFWAVE32 or custom written) must be terminated and started again after power-on of the drive electronics.

NOTE: As of writing of this document, the MFWAVE32 program does not remember settings between program runs. It will always come up with the standard settings displayed in the screenshot above.

## ***Miscellaneous***

For writing custom control programs, MicroFab will supply, upon request, the relevant excerpts from the source of the MFWAVE32 program (written in C++).

In case of problems with the drive electronics, contact (preferably via e-mail):

Hans-Jochen Trost  
 MicroFab Technologies, Inc.  
 1104 Summit Avenue, Suite 110  
 Plano, TX 75074  
 Phone: (972) 578-8076  
 Fax: (972) 423-2438  
 E-mail: [hjtrost@microfab.com](mailto:hjtrost@microfab.com)